SKINFOLD MEASUREMENTS AND THE PERCENTAGE OF BODY FAT DIFFERENCES BETWEEN BLACK AND WHITE MALE SOLDIERS

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AND WHITE MALE SOLDIERS

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Karen Patricia Vaira Hobson, daughter of LTC(Ret) Jack Anthony and Marjorie (Skinner) Vaira, was born December 16, 1947 in Washington, D. C. She attended schools in Virginia, Great Britain, Pennsylvania, Kentucky, and graduated from East Washington High School, Washington, Pennsylvania in 1966. In September 1966 she entered Indiana University of Pennsylvania and received a Bachelor of Science (Institutional Food Service) in May 1970. In July 1970 she entered the U.S. Army as a commissioned officer. She completed a dietetic internship in Denver, Colorado in May 1971. In September 1981, she entered the Graduate School, Georgia State University, Atlanta, Georgia and received a Master of Education (Education Administration and Supervision) in August 1982. She is employed as a dietitian by the U.S. Army and holds the rank of Major. She entered the Graduate School, Auburn University in September 1982. She married George, son of John Cannon (deceased) and Nell (King) Hobson in April 1974.

THESIS ABSTRACT

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This study was conducted to investigate racial differences in skinfold thickness measurements and calculated percent body fat in normal weight basic trainees and overweight career soldiers. It was hypothesized that (a) there is no significant difference between skinfold measurements taken from black soldiers and those taken from white soldiers, and (b) there is no significant difference in percent of body fat between black soldiers and white soldiers as determined by the established method. Height, weight and four skinfold sites were measured on 302 male soldiers (151 black, 151 white), with percent body fat calculated from the sum of the four site measurements. These measurements were grouped in age ranges and compared by race for normal weight trainees and overweight soldiers.

The black soldiers consistently had smaller skinfold measurements, and averaged 2% less body fat than the white soldiers. A significant difference ($P. < .01$) was found for triceps, biceps and iliac crest skinfold thicknesses between the two races. Overweight black soldiers

met the Army established maximum percent body fat twice as often as overweight white soldiers, 16 out of 38 versus 7 out of 38 respectively.

This study indicates that the black soldier had smaller skinfolds and averaged lower percent body fat than the white soldier and that the overweight black soldier was not discriminated against when the sum of four skinfold method was used to determine body fat percentage. As the weight and height for each race within the groups was similar, the smaller skinfold measurements and therefore lower percent body fat of black males provides further support for racial differences in body composition and/or distribution of muscle and subcutaneous fat.

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I express my sincere appreciation to LT Mark Hollaway for his assistance in identifying overweight soldiers, to Mr. Olin F. Bowman for providing office space for soldier measurements, and to Dr. Eugene Dutoit for statistical guidance.

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I. INTRODUCTION

Nutritional assessment using skinfold calipers to evaluate leanness/fatness has been used extensively since the development of calipers. For several years the United States Army has used skinfold measurements to screen its members for leanness/fatness and physical fitness. When an individual exceeds the required weight for height maximum, that person is evaluated on the basis of a percentage body-fat standard. The method for determining body-fat percentage was developed from an all-white sample and may not be applicable to the black soldier.

This research was designed to compare and evaluate the skinfold measurements and body-fat percent determination of male soldiers. It was hypothesized that (a) there is no significant difference between skinfold measurements taken from black soldiers and those taken from white soldiers, and (b) there is no significant difference in percent body fat between black soldiers versus white soldiers as determined by the established method. Skinfold measurements were made during routine physical examinations on basic trainees, and during an overweight screening of career soldiers. Each group was divided by race and age.

II. REVIEW OF LITERATURE

A Historical Overview

Nutritional anthropometry has been used to assess skeletal age, evaluate weight for height as an index of malnutrition, evaluate growth rate, and to indicate overweight and overfat for body composition studies. Nutritional anthropometry is believed to have had its "scientific" beginning with the "sculptor desiring to find the best proportions for the beautiful forms he wished to represent" (1). The first anthropometric index to be used as an indicator of leanness/fatness was the Quetelet Index, weight divided by the square of height, developed by Quetelet of Belgium in 1830. This index is still used today in growth studies (1,2,3). Large-scale nutritional anthropometry can be traced to the French Army of 1812 and the English workhouses of the 1800's. In 1812-1813, the French Government made a survey of all conscripts for height and recorded the numbers rejected for small size, illness or deformities. The results were published by Villermé in 1829. Villermé showed, for the first time, that poverty was clearly associated with short, adult stature and he attributed these effects to poor nutrition and disease during the growth years (1).

The English Parliament commissioned investigations into the conditions of children in the workhouses of the 1830's. Two height and weight surveys showed that the children working in factories were poorly developed and were extremely small in stature by British

standards. The scientific study of growth and development grew rapidly in the late 1800's, aided by the creation of various statistical techniques, which were developed as a consequence of large-scale growth study data (1).

In 1942, the emphasis of nutritional anthropometry changed from growth, development and malnutrition to the understanding of adiposity in man. In that year, the hydrostatic (underwater) method for determining body density was perfected by Behnke (4). The densimetric method (underwater weighing) is based on the principle that body fat weighs less (is less dense) than lean mass tissue, therefore, body density can be calculated using an estimated value for the residual air volume of the lungs at the time of the underwater weighing (5-8). This method assumes the two-component model of body composition which divides the body weight into the lean body mass (LBM) and fat weight (FW) (9). The ratio of FW to body weight is the relative fat content or percent body fat. Relative fat is usually estimated from underwater body density measurements by the Siri equation (495/density) - 450) (10-17). Underwater weighing is considered the best method for determining the two components of body composition but requires extensive time, expensive equipment, highly trained technicians, and considerable subject cooperation, making it impractical for large-scale studies. Today, the hydrostatic method is used primarily in laboratory studies by exercise physiologists, and professional athletes looking for optimal weight proportions (4-8,18).

In 1951, Brozek and Keys (4,19) designed a caliper for measuring skinfold (fatfold) thickness and were the first to use it as a means

of measuring leanness/fatness. The skinfold is also based on the two-component model of body composition. Brozek and Keys stated that next to body-specific gravity measurements, as determined by hydrostatic methods, the skinfold was the best index of percentage of body fat to characterize an individual's leanness/fatness.

Since 1951, extensive research has been done to evaluate and simplify methods for determining body composition in regard to lean body mass and body fat. Prediction equations developed by Allen et al. (4), Pascale et al. (6), Mayhew et al. (7), Jackson and Pollock (8), Wright and Wilmore (10), Sloan (15), and Durnin and Womersley (20), use subcutaneous skinfold measurements, muscle circumferences, and/or skeletal diameters to predict body density, lean body mass, and/or percent of fat. Many large-scale studies have used various skinfold sites for nutritional assessment, body composition determination, and for positioning criteria in sports such as football (7-10,14,15,18-20,23-26). The skinfold caliper is used in almost all nutritional assessment studies today because it is an accurate, inexpensive and practical tool for a large-scale survey.

Skinfold Measurements in Nutritional Assessment

Data obtained using skinfold calipers in nutritional assessment has shown that an individual can be of normal weight but overfat or have excess weight but not be overfat (4,5,10). In a study of professional football players, Wilmore et al. (10,27) demonstrated that the majority of the ball players were grossly overweight by as much as 80-90 pounds according to current height-weight standards, yet by actual measurement, most of the men had less body fat than the

average college male. The use of the caliper also indicates where excess fat is deposited, since fat is not distributed evenly throughout the body. Seltzer and Mayer (28), in a study of 101 particularly obese women, found the triceps skinfold thickness a better criterion as a broad screening device for the definition and diagnosis of obesity than the subscapular skinfold. In a number of the obese women there was a notable absence of a marked excess of fat in the subscapular region, while the thickness of the triceps skinfold in all the women indicated a marked excess of adipose tissue.

What percentage of total body weight should be fat has not been established but various predictive equations, percentiles, and ranges for various body sites have been published (3,4,6-8,20,26,29-32). In 1952, Brozek (4,32) shows a clinically healthy young man, in North America, 25.2 years of age and weighing 70.6 kg having about 14% ether-soluble fat giving a total adiposity of approximately 22.5% of body weight. In a study of 84 healthy middle-aged men (40-55 yrs.) and 95 healthy male college students (18-22 yrs.), Pollock et al. (14) demonstrated the need for separate body density prediction equations for the young and middle-aged men. The mean percent body fat in the young men was 13.4, in the middle-aged men, it was 24.7. Jette (30) used the Durnin and Womersley sum of four skinfold measurement equation to predict percentage of body fat norms for 9642 males in the 1979 Ontario Fitness Study. Jette presented norms by age group for predicting percentage of body fat and percentile scores by age group for the sum of four skinfolds. He established 13-18 percent as the average range for 20-29-year-old males and 18-21 percent for the 30-39-year-old males.

Comparing studies (1951-1967) from various countries for predicting body fat from underwater weighing and skinfold measurements, Sloan (15) found the mean body-fat range for young adult white men was 9-11 percent of body weight. From his own study of underwater weighing versus skinfold, Sloan suggests that 16 percent body fat should be regarded as the upper limit desirable for young men.

It has been estimated that about one-half of the body's total fat lies just under the skin (4). By measuring the subcutaneous fat at specific points it is possible to evaluate fatness levels. A factor which should be considered, when using skinfold measurements of subcutaneous fat, is the "compression factor," which has been shown to vary among sites used, between the sexes, and which can be affected by age, nutritional status, and hydration (33). Six body sites (biceps, triceps, subscapular, suprailiac, chest and abdomen) have been identified as being most representative of overall body fatness (3-6,8,20,34). Pascale et al. (6) in 1956, did correlation analyses of skinfold measurements versus body density on 88 healthy young ($\bar{x}$ age 22.1 yrs.) white soldiers. Their study identified three skinfold sites as the best predictors of body density. The sites identified were midaxillary chestline at the xyphoid level, the chest in the juxta-nipple position, and the triceps midpoint. Allen et al. (4) in 1956, measured the skinfolds at ten body sites on 87 Formosan subjects. The sum of the skinfolds was compared with the percentage of total adiposity, as measured by hydrostatic weighing. Allen found approximately two-thirds of the excess adiposity is located just beneath the skin in fat people while in the thin person most body fat is internal.

Skinfold measurements were taken on large populations during the Ten-State Nutrition Survey, the United States Health Nutrition Examination Surveys (HANES) I and II (sample size 28,043) in the 1970's (2,3,26,29,31,35), and the Fels Longitudinal Study (17). From these studies, Bishop et al. (26), Frisancho (3,31), Garn (2,35), and Himes et al. (17,33) have established norms and percentile distributions for various skinfold locations. Bishop et al. (26,29) and Frisancho (31), using the data from the HANES study, presented different results. Bishop et al. used the total survey sample to determine the norms for upper arm anthropometry, while Frisancho (31,34) excluded the nonwhite subject data from his calculations. Both established age and sex-specific norms for mid-upper arm circumference, triceps skinfold thickness and mid-upper arm muscle circumference of American adults. The norms for male skinfolds decrease until young adulthood and then increase thereafter, while the opposite occurs with female skinfolds (17,26,29,31).

Frisancho (3) correlated the weight to the three indices of obesity (W/H^2, W/H^3, W/H^P) and skinfold thickness by sex and race. He indicated that irrespective of sex or race, the subscapular skinfold correlates higher to the indices that does the triceps skinfold. Himes et al. (17) compared biceps and triceps skinfold thicknesses and corresponding fat areas with body density and found that for males the average of triceps and biceps skinfolds correlated higher with body density than either single skinfold or fat area.

The equations for predicting body density or percentage of fat most frequently used today are those developed by Jackson and Pollock

(8,36) and Durnin and Womersley (20). The Jackson and Pollock method uses either the sum of seven, or three skinfold site measurements, to determine the percentage of body fat in age ranges (36). Durnin and Womersley (20), studying 209 men and 272 women, used the sum of four skinfold thickness sites to develop age and sex-specific body-fat percentages. Both of these methods are easy to use in the clinical setting, as there are minimal calculations to be performed. The YMCA has adopted the Jackson and Pollock equations for use in their adult physical fitness program (36), while the United States Army has adopted the Durnin and Womersley procedures to evaluate the body composition of its members (37).

One consideration when using these predictors of individual body density is that the study samples are of specific populations and may not apply to other populations (16,21-22,35,38-41). Mayhew et al. (7) studied 129 male college athletes and developed regression equations to predict body composition for male athletes. In cross validation of their equations with other widely used prediction equations, Mayhew et al. found that equations derived on nonathletic subjects could not be used effectively to estimate body composition in athletes. With the influence of body composition on athletic performance being widely accepted, closer attention is being given to regulating the various body components in order to maximize competitive capabilities of the individual athlete. The incorrect estimate of body composition from the use of inappropriate equations could cause serious errors and result in adverse advice being given to the athlete concerning dietary habits and/or exercise patterns.

An area of importance for the use of skinfold measurement is nutritional assessment of nonathletes or individuals who are actually obese, but because of their body type, their total body weight may fall within acceptable standards for their age and height. These individuals would probably receive little help in correcting their problem while the athletic-type person might be chastised for being overweight (10). The evaluation of one's fatness is routinely based on deviation from the reference weight for sex, age, and height. Most studies which estimate body density and body fatness indicate maximum predictive accuracy is attained only when the equations are applied to population samples which are similar to those from which the original equations were derived (7,9,11-12,41-42).

Anthropometric Comparison by Race

Most estimations of body composition deal with young adults of European ancestry or persons as part of large samples. Observations on black populations are few. Studies of body composition, using indirect methods or anthropometry indicate that black adults and children tend to have small skinfolds (especially at limb sites) and greater LBM relative to whites (16,21,22,35,38-41,43).

In a study of American black and white children (age 6-13) in Philadelphia over a one-year period, Malina (40) found white children of both sexes consistently had more subcutaneous fat at three skinfold sites (triceps, subscapular, and midaxillary) than did the black children. The racial difference being most marked for the triceps skinfold. Robson et al. (41) presented similar results in a comparison of skinfold thicknesses from a Negroid race in the Caribbean

with reported thicknesses of English schoolboys. The subjects were 1389 infants and children (age 1 month to 11 yrs.) of African ancestry (630 males and 759 females). Triceps and subscapular skinfolds were measured and the means compared. By age, there was a similarity in the trend of skinfold thicknesses at both sites in males and females of European and African origins. While Robson et al. (41) found no significant difference between the subscapular thicknesses of males and females of both races, there was a significant difference between the triceps measurement in both races and sexes. Triceps measurements were much smaller for the Dominican children than the European children.

Koh (38) compared selected anthropometric measurements of a poor black population in Mississippi to the national averages from the HANES, 1971-1972 study. The triceps skinfolds and subscapular skinfolds were compared by sex, for children ages 1-17 years. The black female had smaller triceps measurement averages, except for ages 6 and 10 years, but had larger subscapular skinfold averages in all ages except 7,8,11,12,16 and 17 years. The black males had smaller triceps measurements until the teen years and averaged larger subscapular skinfold measurements in all age years. Koh concluded that "genetic and endocrine mechanisms may override environmental factors such as poor nutrition for these anthropometric measurements" (38).

Harsha et al. (16) measured stature of black and white children, and found a systematic racial and sex difference in body proportions and skinfold measurements. Whites, especially males, tended to have thicker skinfolds at limb sites than blacks. When the median skinfolds

at the limb sites were averaged, the authors found the black boys were 22 percent thinner than white boys. At trunk sites, the racial contrasts diminish to about a one percent difference between the races. Harsha et al. (16) also reported hydrostatic measurements of body density which showed race and sex differences similar to findings from the skinfold study. The correlations between density and the skinfold measurements tend to be greater in blacks than in whites. Body density is inversely correlated with total obesity therefore, the leaner body mass occurs with the higher-density measurement. The black boyd had median density of 1.060 gm/cc while the white boys had median density of 1.049 gm/cc. When converted to percentage of fat by the use of Siri's equation ((495/density) - 450), these density figures yield medians of 16.9 percent for black boys and 21.8 percent for white boys. For optimum prediction of density Harsha recommended separate equations for each race and sex group.

Using the data from HANES-I, Crank and Roche (39) presented percentile values for triceps skinfold thickness at one-year intervals from age 6-17 and three-year intervals for age 18 through 50.9 years for white and black males. Because of the small sample size (978 black males to 4505 white males) the percentiles for blacks are more irregular from age to age than those for whites. Triceps skinfolds for black males are lower than for white males in all age ranges and at all percentile values except the 95th where they are higher. The subscapular skinfold values are similar for corresponding percentiles at most adult ages but black male values are still slightly lower than white male values.

The evidence that the amount of fat in the triceps region is less in black than white races suggests that the use of reference standards, based on data collected from a population composed predominantly of one race, should not be used for evaluating other ethnic groups. Cronk and Roche (39) present separate sets of reference data for black and whites so that individuals can be assigned a percentile rank appropriate to their racial group. Garn, Rosen, and McCann (35) used subscapular and triceps fatfold data and body weight from the Michigan phase of the Ten-State Nutrition Survey to show that skinfolds of black youths were thinner but that black adults had thicker fatfolds than white adults and that the black measurements correlated higher with body weight. The sample was 89 white males, 46 black males, 118 white females and 78 black females. But when Garn and Clark (43) reviewed the entire Ten-State Nutrition Survey their triceps skinfold percentile comparisons showed a lifelong fatness trend with white males fatter than black males from the third year through the ninth decade.

Professional sports and the military are two other areas where anthropometric differences between the races are being considered. Adams et al. (18) studied the body density differences between seven black and seven white professional Canadian football players. Their results showed that when black and white football players are matched somatotypically (type of body build), there is no significant difference in body density values. In 1955, Newman (21) obtained skinfold measurements on 2000 young American men (1702 whites, 292 blacks) before Army basic training. He wanted to examine the idea of utilizing

skinfold measurements of blacks to calculate their body fat, based on prediction equations from white populations (19). Newman stated "any detailed comparison of white and Negro skinfolds is complicated by the fact that Negroids are superficially far leaner than the whites." Newman found a lack of blacks whose skinfold values could be compared with the obese white subjects. Mean skinfold measurements of the arm and chest were lower in the blacks, but mean values for the abdominal skinfold were higher in blacks. Using the Brozek and Keys 1951 prediction equation, Newman made the assumptions that the overall subcutaneous fat to average body density relationship is basically similar in both races and that the black superficial versus deep fat ratio is the same as that found in white subjects. He calculated a percentage of body fat from mean skinfold values and found a one-half of one percent difference between the whites and blacks. From this, Newman concluded that "no great error would result from the use of prediction equations established on white subjects to estimate body fat on Negroids" (21).

In a subsequent study by Newman (22) of skinfold measurements made on 2017 American-born white and 361 American black male United States Army inductees before the start of basic training, he found considerable racial group differences in the amount of body fat. Mean values were 7.4 percent for whites and 4.6 percent for the black soldiers. Newman also found geographical or environmental influences on body fat deposition with the soldiers of both races from the north having greater body fat than those from the south.

Osei-Antwi (44) in 1973, used body fat percentage predictor equations, established on all-white populations, to determine body-fat percentages on black male college students. He compared the results with hydrostatic measurements of body density (percent body fat) and found that the equations of Pascale, et al. and Sloan could be used while the equation from Wilmore and Behnke could not be used to provide reliable information of body density (percent body fat) of black males.

The United States Army (23,37) and United States Marine Corps (10) now use anthropometric methods to evaluate "fatness" in their members. The Marine Corps standard is based on the study of 297 Marines between the ages of 18 and 53 years of all ranks. Circumference measurements of the neck and waist are used to determine percent fat. The Army measures the sums of four skinfolds (triceps, biceps, subscapular and iliac crest) as established by Durnin and Womersley to set percent body fat values for its soldiers. The Army Regulation (37) has established maximum allowable percent body fat standards by sex and age as follows:

Males, 17-20 years	20%
Males, 21-27 years	22%
Males, 28-39 years	24%
Males, 40+ years	26%
Females, 17-20 years	28%
Females, 21-27 years	30%
Females, 28-39 years	32%
Females, 40+ years	34%

In both the Army and Marine Corps, the standards apply to all members regardless of race.

III. EXPERIMENTAL PROCEDURE

This research was approved by the Clinical Research Committee, Martin Army Community Hospital, Fort Benning, Georgia.

Selection of Subjects

Subjects for the study were male soldiers at Fort Benning, Georgia, between 17 and 39 years of age. The purpose and procedures involved in the study were explained to each soldier before the participant signed a volunteer consent form (Appendix A). Four hundred fifty-two soldiers volunteered for the study. However, only 302 soldiers were used as those over 40 years of age, or of other ethnic or racial groups were not included in the analysis.

Subjects were divided into two groups: Group I - young trainees from Regular Army, National Guard, and Reserve units who had just completed seven weeks of infantry basic training and Group II - career soldiers from an infantry brigade who had been identified as overweight by Army height-weight tables (Appendix B). Subjects for Group I were selected at random (1 in 2 blacks, 1 in 5 whites) during a routine physical examination. The number of each race per group was kept equal for statistical comparisons. Each group is subdivided by race. Race was determined visually, by questioning the participant, and from medical history forms. The composition of each group is given in Table 1.

TABLE 1

Distribution of the Subjects
By Race and Age

Age (Yrs)	N	Group I		Group II	
		Black	White	Black	White
17-22	208	92	92	12	12
23-29	84	21	21	21	21
30-39	10	—	—	5	5

Anthropometric Measurements

Height was measured in stocking feet with feet together, back and heels against the upright bars of a height scale, head in the Frankfort horizontal plane ("look straight ahead") and stand erect ("stand up straight"). Weight for Group I was measured in battle dress uniform (BDU) holding boots, with an allowance of 9-12 pounds subtracted from the scale weight according to Army policy. Weight for Group II was measured in gym shorts, T-shirt, and stocking feet. All weights were recorded to the nearest quarter pound.

Four skinfold thickness measurements were taken with a Lange skinfold caliper (Cambridge Scientific Industries, Cambridge, Maryland) calibrated to exert a pressure of 10g/sq mm of jaw surface. All skinfold measurements were taken by the researcher. (The researcher's competence in taking these measurements was established prior to collection of the data. The researcher was credentialed in the use of calipers under the Fort Benning caliper user monitor program). All measurements were taken on the right side of the body, with the subject standing. The sites selected were as follows:

1. Biceps: over the midpoint of the muscle belly with the arm hanging vertically at rest.

2. Triceps: over the midpoint of the muscle belly, midway between the olecranon and the tip of the acromion, with the arm hanging vertically at rest.

3. Subscapular: Just below the tip of the inferior angle of the scapula, at an angle of about 45° to the vertical.

4. Suprailiac: Just above the iliac crest in the mid-axillary line.

At all four sites, the skinfold was pinched up firmly between the thumb and forefinger and pulled away slightly from the underlying tissues before applying the caliper for the measurement. The caliper was applied at a right angle to the fold approximately one centimeter below the thumb. The pressure of the fingers was released momentarily so the pressure at the time of measurement was exerted by the caliper and not by the fingers.

A reading was taken and recorded at each of the four skinfold sites and then repeated twice more in succession. Readings were taken to the nearest 0.5mm. The three readings at each site were averaged to the nearest tenth of a millimeter and the average values totaled to give the sum of four skinfolds for obtaining percent body-fat value from the Durnin and Womersley (20) table (Appendix C).

Analysis of Data

The mean and standard deviation for each skinfold site was computed and compared by age range and race for Group I and Group II. The computed body-fat percent values were compared by age and race. The statistical test for homogeneity of the variance/covariance matrices of both groups was computed at the United States Army Infantry Center using the Statistical Package for the Social Sciences (SPSS) update 7-9 (45). Wilk's Lambda multivariate test statistic (46) was used to compare the responses between the two races in each group. Bartlett's test of sphericity (46) was computed to determine if there was at least one significant correlation between a pair of dependent variables. The data was treated with canonical correlation analysis

which evaluates intercorrelations among variables to determine if a particular type of patterning exists in the data. Hypothesis testing was done at a level of significance of 0.05.

IV. RESULTS AND DISCUSSION

This study was conducted to ascertain the differences between skinfold measurements taken from black soldiers versus those from white soldiers and the differences in percent body fat between black soldiers and white soldiers as determined by the established method.

Little differences were found between black and white soldiers for height or weight in either the normal weight basic trainees (Group I) or the overweight soldiers (Group II). Differences were found for all the skinfold thickness measurements with the triceps, biceps and iliac crest sites being significant. Black males consistently had smaller skinfold measurements, averaging 2mm less per site measured than white males for Group I and 3.5mm less per site measured in Group II. Body-fat percentage, based on the method of Durnin and Womersley (20), was computed from the sum of four skinfolds for all subjects. There was a wide range of values in both groups, but the black soldier consistently had lower percentages of body fat.

Group I: Comparison of Skinfold Thickness and Body-Fat Percent

The anthropometric data by race and age for Group I is given in Table 2. The majority of Group I (81%) were trainees directly from high school where physical exercise and/or sports participation (football, basketball, wrestling, track) had been routine. All soldiers in this group had successfully completed seven weeks of basic infantry training which included physical training--aerobic exercise (running)

TABLE 2

Anthropometric Measurements* By Race and Age
For Basic Trainees (Group I)

Race	N	Age	Height(in)	Weight(lbs)	Skinfolds(mm) Triceps	Biceps	Subscapular	Iliac crest	Body fat** %
Black									
17-22 yrs	92	18.6±1.7	69.5±2.7	155.3±18.6	10.3±3.8	5.8±1.5	13.2±7.3	13.9±4.0	16.4±3.0
23-29 yrs	21	24.9±1.7	70.5±2.4	168.9±23.2	11.1±4.8	6.3±2.3	14.3±4.6	18.0±8.2	17.7±4.9
All	113	19.8±3.0	69.7±2.7	156.4±24.1	10.5±4.1 [a]	5.9±1.7 [a]	12.6±4.0 [a]	14.7±5.3 [a]	16.6±3.5 [a]
White									
17-22 yrs	92	18.3±2.4	70.0±2.7	154.2±21.4	13.4±4.5	7.0±2.3	13.2±4.0	16.5±5.5	18.3±3.5
23-29 yrs	21	24.7±2.1	70.9±2.0	167.6±20.2	13.3±4.9	6.9±2.1	14.0±6.0	19.2±6.6	19.0±3.9
All	113	19.5±3.4	70.2±2.6	156.7±21.8	13.9±6.5 [b]	6.9±2.3 [b]	13.4±4.4 [a]	16.8±6.0 [b]	18.4±3.6 [b]

* Mean ± standard deviation.

** Percent body fat determined from Durnin and Womersley table (20).

Means not sharing a common superscript are significantly different by f test at P 0.01.

each day. These soldiers were considered to be at normal weight, although some reported weight loss (5-15 lbs) or gain (2-5 lbs) during training.

Significant differences ($P < .01$) were found for the triceps, biceps and iliac crest skinfold thicknesses between the black and white soldiers. The black male had smaller skinfold thicknesses in both age groups in all but the subscapular site. Newman (21,22) found similar lower skinfold thicknesses for the arms and chest sites of black versus white males. The statistical test for homogeneity of the variance/covariance matrices of both races was computed. Box's M test was computed and the null hypothesis was rejected at the 0.05 level (Box's M=35.7, P=0.000). The variance/covariance matrices were not equal, therefore that particular assumption regarding multivariate procedures was not strictly satisfied. Bartlett's test of sphericity was computed to determine if there was at least one significant correlation between a pair of dependent variables. The null hypothesis was rejected (Bartlett's test of sphericity = 638.95; P=0.000). Rejection of the null hypothesis by Bartlett's test of sphericity concluded that there was at least one significant correlation between the pair of dependent variables; therefore the assumption of sphericity for multivariate procedure was valid. Multivariate procedures should be as insensitive to violations of distributional assumptions as univariate tests (46-48). Univariate tests are insensitive to violations of assumptions made especially when sample sizes are equal (48). As Bartlett's test rejected the null hypothesis and sample sizes were equal, the multivariate method was considered appropriate for analysis of the data.

The Wilk's Lambda multivariate test of significance was used to compare the response between the two races. Hypothesis testing was done at a level of significance of 0.05. The value of Lambda was 0.848; the level of significance was $P=0.000$. The test result indicated there was a statistically significant difference between the two races for the skinfold measurement variables. Table 3 gives the analysis of variance for the four skinfolds. Significant differences were found for the triceps, biceps and iliac crest skinfold thicknesses between the races with univariate F-test, ($P < 0.01$). The subscapular skinfold did not prove significantly different.

Body-fat percentage mean values are shown in Table 2. Group I soldiers were considered to be at normal weight, therefore they would not normally be subject to meeting the established body-fat percent standard (Appendix B). The black soldier averaged 1.76% less body fat than the white soldier of the same age. Table 4 gives the percent of soldiers by race and age who met or exceeded the established percent body fat for age. Fifteen of the 113 normal weight black soldiers exceeded the maximum allowable percent body fat, while 31 of the white soldiers exceeded the maximum for their age. This may indicate the condition of overfat at a normal weight for height standard. As the height and weights were similar, the smaller skinfolds for blacks may indicate a difference in muscle/fat distribution.

The accuracy of the Durnin and Womersley method (20) to predict body-fat percent in blacks has not been verified. Newman (21), in 1955, concluded that no error would be introduced by using predictor regression equations from white studies to evaluate black males, but

TABLE 3

Analysis of Variance for Group I
Skinfold Thickness

Variable	Univariate F Test	
Skinfold Thickness		P=*
Triceps	25.607	0.000
Biceps	16.740	0.000
Subscapular	1.170	0.280
Iliac crest	9.484	0.002

* P<0.01

TABLE 4

Percent Meeting or Exceeding Body Fat
Percent Standards* in Group I

		Black (n=113)		White (n=113)	
		Regulation Standard			
		Percent		Percent	
Age (yrs)	N	Met	Exceeded	Met	Exceeded
17-22	(92)	89.1	10.9	70.6	29.4
23-29	(21)	76.2	23.8	80.9	19.1
All	(113)	86.7	13.3	72.6	27.4

* Department of the Army. (1983) Army Regulation 600-9: The Army weight control program. pp. 1-6, Washington, D.C.

reversed his conclusion in 1956 (22) when he found considerable racial differences in the amount of body fat between black and white males. Black males in the present study had small skinfold thicknesses, therefore when summed, a lower percent body fat would result. Osei-Antwi (44) found that not all predictor equations for body-fat percent determination, based on white population, could be used to reliably predict body fat in black males. He found predictor equations based on multiple skinfolds were better than equations using other types of measurements (circumference, diameter).

Group II: Comparison of Skinfold Thickness and Body-Fat Percent

The anthropometric data by race and age for Group II are given in Table 5. All soldiers in this group were assigned to an infantry brigade and had been identified as overweight for age and height according to Army regulations (37) (Appendix B). Officers and enlisted men are included in this group.

Statistical test results for Group II are similar to Group I results. Significant differences ($P < .05$) were found for the triceps, biceps and iliac crest skinfold thickness between the black and white soldier. The black male had smaller skinfold thicknesses in all age ranges and averaged 2% less body fat. The statistical test for homogeneity of the variance/covariance matrices of both races was computed. Box's M test did not reject the null hypothesis at the 0.05 level (Box's M=7.558, P=.714). Bartlett's test of sphericity was computed to determine if there was at least one significant correlation between a pair of dependable variables. The null hypothesis was rejected (Bartlett's test of sphericity=121.425; P=0.000) concluding that there was at

least one significant correlation between the pair of dependent variables.

The Wilk's Lambda multivariate test of significance was used to compare the response between the two races. The test was significant at a level of 0.05. The value of Lambda at 0.7605 within the level of significance 0.001, indicated a statistically significant difference between the two races.

The analysis of variance for the four skinfolds is reported in Table 6. Significant differences were found for the triceps, biceps and iliac crest skinfold thicknesses for the black versus the white soldiers. The subscapular thickness was smaller for the black soldier but the difference was not significant.

Body-fat percentage mean values are shown in Table 5. Group II soldiers had been identified as overweight for height/weight standards and required percent body fat determination. The heaviest black soldier was 72" tall and 241 lbs (46 lbs overweight), and the heaviest white soldier was 74" tall and 248 ½ lbs (42 lbs overweight). The most overweight for height was a white soldier, 70" tall and 235 lbs (50 lbs over standard), with the group average being thirty pounds over height-age allowable maximum. These soldiers were required to meet the percent body fat maximum for age and/or required to lose sufficient weight to meet the weight-height table (Appendix B).

Table 7 gives the percent of soldiers who met or exceeded the body-fat percent standard. Sixteen of the 38 black overweight soldiers were not "overfat" when percent body fat was determined by the Durnin and Womersley method, and 7 of the 38 white met the standard. When an

TABLE 5

Anthropometric Measurements* By Race and Age
For Overweight Soldiers (Group II)

					Skinfolds(mm)				
Race	N	Age	Height(in)	Weight(lbs)	Triceps	Biceps	Subscapular	Iliac crest	Body fat ** %
Black									
17-22 yrs	12	20.1 ± 1.4	69.3 ± 2.3	190.8 ± 16.6	18.3 ± 3.2	8.7 ± 2.3	20.7 ± 4.5	25.9 ± 8.5	22.8 ± 3.0
23-39 yrs	21	25.1 ± 1.8	69.9 ± 2.7	200.0 ± 16.1	16.0 ± 5.1	7.9 ± 2.8	19.9 ± 4.5	24.0 ± 7.0	22.0 ± 3.2
30-39 yrs	5	31.8 ± 2.2	70.0 ± 1.4	199.8 ± 8.0	15.5 ± 5.0	6.5 ± 1.7	24.8 ± 6.2	26.2 ± 9.0	24.7 ± 3.7
All	38	24.4 ± 4.1	69.8 ± 2.4	197.1 ± 16.1	16.7 ± 4.7^{a}	8.0 ± 2.6^{a}	20.8 ± 5.0^{a}	24.9 ± 7.8^{a}	22.6 ± 3.3^{a}
White									
17-22 yrs	12	20.2 ± 1.4	71.4 ± 2.7	208.3 ± 22.9	21.6 ± 3.6	9.3 ± 2.1	20.2 ± 5.2	28.7 ± 9.6	24.0 ± 2.9
23-39 yrs	21	25.2 ± 1.8	69.3 ± 2.2	195.9 ± 19.2	21.3 ± 5.2	9.2 ± 2.4	23.5 ± 6.1	28.9 ± 6.0	24.5 ± 3.0
30-39 yrs	5	33.6 ± 2.7	68.0 ± 0.9	194.4 ± 5.1	23.3 ± 3.3	10.8 ± 1.9	27.5 ± 2.2	34.1 ± 6.8	28.0 ± 1.4
All	38	24.7 ± 4.5	69.8 ± 2.5	199.7 ± 20.2	21.5 ± 4.5^{b}	9.4 ± 2.3^{b}	23.0 ± 5.9^{a}	29.6 ± 7.6^{b}	24.3 ± 4.7^{b}

* Mean and standard deviation.

** Percent body determined from Durnin and Womersley table (20).

Means not sharing a common superscript are significantly different by f test at P 0.05.

TABLE 6

Analysis of Variance for Group II
Skinfold Thickness

Variable	Univariate F Test	
Skinfold Thickness		P=*
Triceps	20.427	0.000
Biceps	6.249	0.015
Subscapular	3.015	0.087
Iliac crest	6.753	0.011

* $P < .05$

TABLE 7

Percent Meeting or Exceeding Body Fat
Percent Standards* in Group II

		Black (n=38)		White (n=38)	
		Regulation Standard			
		Percent		Percent	
Age (yrs)	N	Met	Exceeded	Met	Exceeded
17-22	(12)	41.7	58.3	16.7	83.3
23-39	(21)	47.6	52.4	23.8	76.2
30-39	(5)	20.0	80.0	- -	100.0
All	(38)	42.0	58.0	18.4	81.6

* Department of the Army. (1983) Army Regulation 600-9: The Army weight control program. pp. 1-6, Washington, D.C.

overweight soldier meets the body-fat percent standard, he is not required to lose his excess weight, as it is considered to be lean body mass.

It has not been shown that the regression equation for predicting percent body fat developed by Durnin & Womersley (20) would or would not be applicable to nonwhite populations. Osei-Antwi (44) did show that predictor regression equations developed by Pascale and Sloan can be used to reliably measure body density (percent body fat) in black males, although the equations had been tested and established on all-white populations. This was not true for other equations he tested.

The intended use of the Durnin and Womersley (20) method by the United States Army is to evaluate leanness/fatness in its members. Although this method has not been tested for reliability or accuracy in predicting body-fat percentage in blacks, the fact that blacks had smaller skinfold thicknesses and averaged lower percent body fat, from the sum of four skinfolds, means the black soldier will more frequently meet the standard when identified as overweight and thus is not discriminated against by the use of this standard. Many of the overweight black soldiers in this study were actively involved in competitive sports programs within their military unit or were weightlifting, which may decrease the subcutaneous body fat. This could explain the high number of blacks identified as overweight for height, who were actually very lean by percent body fat-evaluation.

V. SUMMARY AND CONCLUSION

Significant differences ($P < .01$) between races were found in three of four skinfold thickness measurements taken from normal and overweight soldiers. The black soldiers consistently had smaller skinfold thicknesses and percent body fat determinations than white soldiers of like age, body weight, and height.

Thirty-one of the 113 normal weight white soldiers, not subject to percent body fat standards, had excess body fat while only 15 of the 113 normal weight black soldiers were considered to have excess body fat. Sixteen of the 38 black and 7 of the 38 white soldiers identified as overweight were not overfat by percent body fat standards.

It can be concluded that the use of the sum of four skinfold measurements to predict body-fat percent, in the evaluation of the overweight soldier, does not discriminate against the overweight black soldier, although the method was established on an all-white population. The need for a consistent, easy evaluation method for the overweight versus overfat soldier would support continued use of the Durnin and Womersley standard until such time as it is proven inappropriate for nonwhite populations.

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APPENDIX A

PATIENT EXPLANATION CONSENT SHEET

INSTITUTE: Auburn University

TITLE OF PROTOCOL: Skinfold Measurements and the Percentage of Body Fat Differences Between Black and White Male Soldiers.

PRINCIPAL INVESTIGATOR: Karen P. Hobson, Major, AMSC, Auburn University (404-327-6001)

PARTICIPATION INFORMATION: You have been asked to volunteer to participate in a research study conducted at Auburn University. It is very important you understand the following general principles which apply to all participants in our studies whether normal or patient volunteers: (a) your participation is entirely voluntary; (b) you may withdraw from participation in this study at any time. Refusal to participate will involve no penalty or loss of benefits to which you are entitled; (c) after the explanation please feel free to ask any questions that will allow you to clearly understand the nature of the study.

NATURE OF STUDY: This study is to compare skinfold measurements taken on male soldiers who have been identified for the Army Overweight Program and to evaluate the need for a race-specific standard. The subjects will be measured with Lange skinfold calipers on four body sites (biceps, triceps, subscapular and suprailiac) during one appointment. This investigation is being conducted as a Master's thesis and because there are no skinfold measurements, body-fat percentage standards established by race. This study is to involve approximately 500 male soldiers.

BENEFIT: You will not benefit directly from this study, but the study may contribute information to better evaluate the overweight soldiers.

DURATION OF THE STUDY: This study will involve one 30-minute appointment.

RISKS, INCONVENIENCES AND DISCOMFORTS: There are no risks involved with this study. The subject will be "pinched" on four body sites. There are no drugs or side effects involved with this study.

SIGNATURES:

PATIENT/VOLUNTEER SIGNATURE

DATE

WITNESS

TIME

APPENDIX A

VOLUNTEER AGREEMENT

I, ____________________________, currently residing at ____________________ having attained my ________ birthday on ________________ and otherwise having full capacity to consent, do hereby volunteer to participate in a clinical investigation study entitled: Skinfold Measurements and the Percentage Body Fat Differences Between Black and White Male Soldiers under the direction of Karen P. Hobson RD, MAJOR AMSC. The implications of my voluntary participation; the nature, duration and purpose; the methods and means by which it is to be conducted; and the inconveniences and hazards which may reasonably be expected have been explained to me by Karen P. Hobson, and are set forth on the reverse side of this agreement, which I have initialed. I have been given an opportunity to ask questions concerning this clinical investigational study, and any such questions have been answered to my full and complete satisfaction.

I understand that I may at any time during the course of this study, revoke my consent, and withdraw from the study without prejudice; however I may be requested to undergo certain further examinations, if in the opinion of the attending physician, such examinations are necessary for my health or well being.

________________________ ____________
Signature Date

I was present during the explanation referred to above, as well as the volunteer's opportunity for questions, and hereby witness the volunteer's signature.

________________________ ____________
Witness' Signature Date

APPENDIX B

BODY FAT PERCENTAGES

The maximum allowable percent body fat standards are as follows:

Age Group			
17-20	21-27	28-39	40 + Older
20	22	24	26

However, all personnel are encouraged to achieve the more stringent DOD-wide goal, which is 20 percent body fat for males.

WEIGHT FOR HEIGHT TABLE
(screening table weight)

	Age Group			
HT	17-20	21-27	28-39	40+
58	—	—	—	—
59	—	—	—	—
60	132	136	139	141
61	136	140	144	146
62	141	144	148	150
63	145	149	153	155
64	150	154	158	160
65	155	159	163	165
66	160	163	168	170
67	165	169	174	176
68	170	174	179	181
69	175	179	184	186
70	180	185	189	192
71	185	189	194	197
72	190	195	200	203
73	195	200	205	208
74	201	206	211	214
75	206	212	217	220
76	212	217	223	226
77	218	223	229	232
78	223	229	235	238
79	229	235	241	244
80	234	240	247	250

APPENDIX C

THE EQUIVALENT FAT CONTENT, AS A PERCENTAGE OF BODY-WEIGHT,* FOR A RANGE OF VALUES FOR THE SUM OF FOUR SKINFOLDS (BICEPS, TRICEPS, SUBSCAPULAR AND SUPRAILIAC) OF DIFFERENT AGES.

Skinfolds (mm)	(age in years) 17-29	30-39	40-49	50+	Skinfolds (mm)	(age in years) 17-29	30-39	40-49	50+
15	4.8	- -	- -	- -	115	29.4	30.6	36.4	39.7
20	8.1	12.2	12.2	12.6	120	30.0	31.1	37.0	40.4
25	10.5	14.2	15.0	15.6	125	30.5	31.5	37.6	41.1
30	12.9	16.2	17.7	18.6	130	31.0	31.9	38.2	41.8
35	14.7	17.7	19.6	20.8	135	31.5	32.3	38.7	42.4
40	16.4	19.2	21.4	22.9	140	32.0	32.7	39.2	43.0
45	17.7	20.4	23.0	24.7	145	32.5	33.1	39.7	43.6
50	19.0	21.5	24.6	26.5	150	32.9	33.5	40.2	44.1
55	20.1	22.5	25.9	27.9	155	33.3	33.9	40.7	44.6
60	21.2	23.5	27.1	29.2	160	33.7	34.3	41.2	45.1
65	22.2	24.3	28.2	30.4	165	34.1	34.6	41.6	45.6
70	23.1	25.1	29.3	31.6	170	34.5	34.8	42.0	46.1
75	24.0	25.9	30.3	32.7	175	34.9	- -	- -	- -
80	24.8	26.6	31.2	33.8	180	35.3	- -	- -	- -
85	25.5	27.2	32.1	34.8	185	35.6	- -	- -	- -
90	26.2	27.8	33.0	35.8	190	35.9	- -	- -	- -
95	26.9	28.4	33.7	36.6	195	- -	- -	- -	- -
100	27.6	29.0	34.4	37.4	200	- -	- -	- -	- -
105	28.2	29.6	35.1	38.2	205	- -	- -	- -	- -
110	28.8	30.1	35.8	39.0	210	- -	- -	- -	- -

* In two-thirds of the instances the error was within $\pm 3.5\%$.

Source: Durnin and Womersley; British Journal of Nutrition, Vol 32, p. 95, 1974.